

# **TINTED HOLOGRAPHIC PRINTING MATERIAL**

## **FIELD OF THE INVENTION**

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The present invention relates to the field of holographic or optically variable media, a method of providing holographic or optically variable media, and a method for forming holograms or optically variable images on a substrate. More particularly, a multilayered holographic or optically variable material comprising a plurality of embossed panels individually tinted in the YMCK primary colors is provided to print an individually customized colored holographic or optically variable image onto a substrate by transferring pixels from one or more panels onto the substrate.

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## **BACKGROUND OF THE INVENTION**

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Holography or optically variable images have been used in the applications when it is desirable to reproduce the appearance of a one, two or three-dimensional images on various substrates. Reflective transparent, semitransparent, and opaque materials containing embossed holographic images can be used in decorative and security applications. One of the applications of thin films containing holographic or optically variable images is document protection, such as passports, credit cards, security passes, licenses, stamps and the like. Protection is achieved by affixing holographic or optically variable films to the documents, therefore making it very difficult to forge and counterfeit such documents.

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An example of a holographic or optically variable film can be found in U.S. Patent 5,781,316 to Strahl et al., which teaches applying a semi-transparent holographic or optically variable transfer foil film to a substrate, such as a security device. The film described in that patent comprises a thermally stable carrier for supporting multiple thermoplastic or thermoset layers. A heat sensitive release layer is applied to the carrier to enable separation of the carrier from the multiple layers of coatings. A wear-resistant transparent topcoat is applied over the release layer to act as an outer surface for the holographic film. The topcoat may be treated or cured in order to increase its tenacity. An embossable layer applied over the topcoat is adapted to retain the impression of an

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embossed holographic image. A semi-transparent reflective layer of ZnS is applied over the embossable layer for reflecting the embossed holographic or optically variable image and enabling a viewer to see the holographic or optically variable indicia transferred onto the substrate or document. A surface relief pattern is impressed within the reflective layer and the embossable layer to form the embossed holographic or optically variable image. Adhesive and primer or tie layers are also applied for adhering the semi-transparent holographic coating to the substrate.

Although the method described in that patent works to reduce the possibility of forgery of a security document such as an ID card, some risk of forgery or counterfeiting continues to exist. To improve the security of a paper document or a plastic card, a more personalized security hologram or optically variable image may be desirable. Thermal transfer printing is one way of recording and printing variable personalized information on various substrates. A more complex holographic or optically variable image can be created using thermal transfer printers and thermal transfer ribbons, as described in U.S. Patent 5,342,672 to Killey. However, the hologram described in that patent is opaque and therefore not suitable for application on an ID card or other security documents where the personalized individual data needs to be protected from alteration.

Accordingly, there is a need for a semi-transparent holographic thermal transfer recording material, which can be applied onto various documents in a individually customized manner for protection and counterfeit prevention purposes.

To print an image by thermal transfer printing using an ink ribbon, the print head of the printer contacts the polymer (or dye diffusion) ribbon and transfers ink to particular locations on the surface of a print medium. The printer head thermally activates the predetermined combinations of heating elements, which are adjacent to the image-forming locations. The ink/carrier structure is locally heated by the heating elements to a temperature at or above the melting point of the ink. In this manner, the necessary amount of ink softens and adheres to the print medium at the predetermined locations to form the image.

Color images are printed with an ink/carrier structure, such as a ribbon, that includes separate regions or panels of differently colored inks, such as the subtractive primary colors, yellow, magenta, and cyan. Color printing is accomplished by

sequentially passing the print head along the ribbon, each pass selectively transferring different colored inks to the desired locations on the substrate at predetermined times.

Thermal printing ribbons are available with a single black panel, three color panels (yellow, magenta, and cyan), or four color panels, (yellow, magenta, cyan, and black).

- 5 Such thermal printing process allows a user to create a highly customized color picture or image on the substrate.

## SUMMARY OF THE INVENTION

- 10 The present invention is a holographic or optically variable transfer material for application to a substrate, such as a document or device. The first side of the material comprises a thermally stable carrier such as PET, for supporting multiple thermoplastic or thermoset coatings or layers. A release layer is the first layer applied to the carrier to facilitate separation of the carrier from the multiple layers when they are subjected to heat
- 15 from the thermal print head. A wear resistance topcoat may then be applied over the release layer to serve as the outer surface of the hologram or optically variable image. An embossable layer is applied over the topcoat. A semi-transparent reflective layer of ZnS or possibly Aluminum in the case of a opaque security image is applied over the embossable layer. A tie or primer coating and heat activated adhesive layer are the layers
- 20 providing the adherence of the transferable holographic material to the chosen substrate. The "embossment" pressed into the embossable layer consists of consecutive sections or panels. Either of the layers can be tinted with one of the primary colors, such as yellow-magenta-cyan-black. Preferably, it is the embossed layer which is tinted in such a way that each individually embossed panel is tinted in one of the primary colors. Each of the
- 25 panels is configured in such a way that it reflects incoming light at a certain distinct angle of reflection. A panel reflecting at a predetermined angle can be made by either embossing the panel to reflect at the predetermined holographic reflective angle (using a conventional holographic table), or by digitally creating the optically variable panel by embossing it from a plate or shim produced in a pixel-by-pixel manner (for example, by
- 30 using a computer controlled origination machine). Using the latter method, each tinted panel of the present invention comprises the pixels that can later be transferred onto the

substrate in the process of forming a customized holographic or optically variable image. All pixels disposed in a particular panel reflect incoming light at the same angle, which angle is different from the angle at which incoming light is reflected by all pixels disposed in another panel. Similarly, if each panel comprises an embossment of a  
5 holographically reflective or optically variable angle, then each panel of the present invention will reflect incoming light at a distinct predetermined angle of reflection. The resulting final image on the substrate can be composed of blended individual tinted dots or stand alone tinted dots. In the case where the dots are blended, their combined primary colors provide a holographic appearance of the natural coloration of that dot in a photo or  
10 any other image of the like quality.

An eye-mark or registration bar to position each panel for registered printing can be provided on either the coated side or the carrier side of the product. The carrier side of the holographic or optically variable transfer material can also include coatings which eliminate blocking of the coatings as well as increase the “slip” of the transfer material  
15 against the thermal head of a printer.

Using the material and method of transferring of a holographic or optically variable image described above, a personalized or customized holographic or optically variable image can be printed on a substrate by sequentially passing the holographic or optically variable transfer material, such as a ribbon, past the thermal print head of a  
20 thermal transfer printer. Each such pass will selectively transfer the material in a pixel-by-pixel manner, or other selective pixel manner, from different panels, so that a custom image analogous to a “conventionally produced optically variable image” with holographic appearance can be printed on a substrate. For example, the transfer process can involve selectively transferring all the image forming pixels from the panel reflecting at angle  $\alpha_1$ ,  
25 then selectively transferring all the image forming pixels from the panels reflecting at angle  $\alpha_2$ , and so on as many times as required by the structure of the image or a certain application or program. The resulting final image will consist of the blended or stand alone transferred pixels.

Other features and advantages of the invention will become apparent to those  
30 skilled in the art upon review of the following detailed description, claims and drawings in which like numerals are used to designate like features.

## BRIEF DESCRIPTION OF THE DRAWING FIGURES

FIG. 1 is a cross-sectional view of the material of the present invention.

FIG. 2 is a cross-sectional view of two embossed panels.

5        FIG. 3 is a schematic view of a ribbon embodiment of the present invention with tinted panels.

FIG. 4 is schematic illustration of a specific ID zone in an image.

FIG. 5 is schematic illustration of a customized printing arrangement.

Before the embodiments of the invention are explained in detail, it is to be  
10       understood that the invention is not limited in its application to the details of construction and the arrangement of the components set forth in the following description or illustrated in the drawings. The invention is capable of other embodiments and of being practiced or being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein are for the purpose of description and should  
15       not be regarded as limiting. The use of "including" and "comprising" and variations thereof is meant to encompass the items listed thereafter and equivalents thereof as well as additional items and equivalents thereof.

## DETAILED DESCRIPTION OF THE INVENTION

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Shown in FIG. 1 is a cross-section of a tinted transfer material 10 containing holographically or optically variable embossed panels 20 and 22 according to the present invention. Alternatively, panels 20 and 22 can be provided digitally as described in the Summary section of this description. In a particular embodiment illustrated in FIG. 1,  
25       transfer material 10 is a film or a ribbon. Material 10 comprises multiple layers, which are applied during various stages of the manufacturing process. Either of the layers can be tinted to provide the desired tinting effect. A thermally stable layer 12 can be made of polyester or any other suitable thermally stable material onto which other layers can be deposited. A release layer 14 is disposed on thermally stable layer 12 to later separate  
30       layer 12 from other layers. Release layer 14 typically comprises a wax or any other

suitable thermoplastic material, which softens at a certain temperature and allows the thermally stable layer 12 to be removed or released upon thermal activation of layer 14.

5 A wear resistant layer called a top coat 15 is applied on top of release layer 14 to act as the top layer of material 10, once thermally stable layer 12 and release layer 14 are removed. Wear resistant layer 15 is preferably transparent, but it is also contemplated that it can be tinted to better display a holographic or optically variable image embossed in material 10. Wear resistant layer 15 can be made of urethane, acrylic, vinyl or any other tear, mar, scratch and wear or chemical resistant material. Deposition of wear resistant layer 15 is typically performed via coating, casting, laminating or other known method, depending on the desired thickness. Wear resistant layer 15 can be applied by means of gravure, reverse roller, mayer bar, coextrusion or lamination, and can be treated by means of an electron beam in order to change the properties of the layer. It also can be air dried, heat set, UV cured or laminated in order to acquire tenacity.

15 An embossable layer 16 is next applied over wear resistant layer 15. Embossable layer 16 is preferably made of a thermoplastic resin comprised of urethane or any other suitable material. Embossable layer 16 is an impressionable layer, which effectively has a memory to retain the embossed image. Thus, embossable layer 16 will retain any impression formed therein. Embossable layer 16 comprises more than one portion, called panels, such as, for example, panel 20 and panel 22. Each one of panels 20 and 22 is comprised of the pixels forming embossable layer 16. Each one of panels 20 and 22 is embossed to reflect incoming light only at a certain predetermined angle. Alternatively, panels 20 and 22 are comprised of the pixels that reflect light at predetermined angles; the angle at which the pixels of panel 20 are recorded is different from that at which the pixels on panel 22 are recorded. In other words, each of the panels of embossable layer 25 16 is either embossed or digitally recorded at a different angle.

FIG. 2 illustrates the concept of the embossable panels of the present invention in more detail. Illustrated there is transfer holographic or optically variable material 10 having embossable layer 16 comprising panel 20 adjacent to consecutive panel 22. Embossed in panel 20 are a plurality of pixels (shown as 1 to n for the purposes of convenient illustration) recorded to reflect incoming light 24 at angle  $\alpha_1$ . (As a matter of terminology, it should be understood that each pixel, whether embossed or digitally

recorded, comprises a diffraction grating of a certain pitch and orientation. Incoming light 24 illuminates the pixels and diffracts on them. Light diffracting on pixels 1 to n in panel 20 becomes diffracted outgoing light at angle  $\alpha_1$  (shown as light 23 in FIG. 2).

Throughout this description the outgoing light (as light 23 and 25 in FIG. 2) is called  
5 “reflected” or “diffracted”.) To rephrase, all pixels embossed in panel 20 of embossable layer 16 reflect incoming light at the same angle  $\alpha_1$ , meaning that the whole area of panel 20 is assigned an angle,  $\alpha_1$ , at which all the pixels disposed in panel 20 reflect incoming light 24. In a similar fashion, embossed in panel 22 are a plurality of pixels (shown as 1’ to m’ for the purposes of convenient illustration, m’ can be equal to n or it can be  
10 different from n) recorded to reflect incoming light 24 at angle  $\alpha_2$ . All pixels embossed in panel 22 of embossable layer 16 reflect incoming light at the same angle  $\alpha_2$ , meaning that the whole area of panel 22 is assigned an angle,  $\alpha_2$ , at which all the pixels disposed in panel 20 reflect incoming light 24. Alternatively to digitally creating panels 20 and 22 in a pixel-by-pixel manner, each panel can comprise an embossment of a certain  
15 predetermined holographic or optically variable reflecting angle provided by any conventional holographic embossing method. Holographic transfer material 10 can comprise as many such panels embossed (or recorded) and reflecting light at different angles as it may be called for by a particular application.

Turning again to FIG. 1, a semi-transparent reflective layer 17 is deposited onto  
20 the embossable layer 16. As mentioned previously, the semi-transparent reflective layer allows a reader to view the embossed panels of the embossable layer when the panels are illuminated at a predetermined angle. A customized image on substrate 11 formed by transferring pixels in a selective pixel-by-pixel manner from the panels onto the substrate will also be viewable. Semi-transparent or opaque layer 17 preferably comprises ZnS or  
25 Al applied by any means suitable for such application.

A tie or primer layer 18 may be applied over reflective layer 17 to increase interfacial adhesion. The tie or primer layer can be made of any chemical composition which increases the interfacial adhesion between the reflective layer and the adhesive. A heat activated adhesive layer 13 is applied on top of tie layer 18. When heat, such as the  
30 heat from a thermal printer print head, is applied to material 10, the release layer 14 releases the coatings from the PET carrier 12 and the adhesive in adhesive layer 13 is

activated, attaching material 10 to substrate 11. Substrate 11 can be made of paper, teslin or plastic.

With regard to applying the tinting color to the holographic printing material, it is contemplated that either of the layers comprising the material can be tinted with semi-transparent dyes to achieve the desired tint. In the preferred embodiment of the invention it is the embossing layer that is tinted. The tinting process can be the following. The top coat 15 is usually applied by a gravure process which lays down a wet coating across the entire width and length of the film. By adding a multi-station gravure system to the embossing process, one can coat or print a series of panels that are registered to the embossing station, so that each embossed panel will be placed against its assigned tinted area. The result of such process is a holographic material that exhibits a series of specifically tinted panels. When heat is applied to such a panel, either by a thermal print head or by another heating mechanism, the panels will transfer onto a substrate a series of pixels that produce a picture, logo, lettering etc. The transferred holographic pixels could be blended (to provide a "lithographic or photo quality look") or stand alone (to provide a "comic book look"). The blended color is provided by overlapping tinted dots transferred from the respective tinted panels to the substrate. The layout of the dots, as well as a particular way of how they could overlap, is controlled by an accordingly programmed computer.

One of the embodiments of holographic or optically variable transfer material 10 according to the present invention is illustrated in FIG. 3. Material 10 is depicted in the form of a ribbon, similar to the shape of the ribbons used in thermal ink printing. The illustrative ribbon comprises holographic or optically variable panels 20, 22, 26, and 28 provided as described with regard to FIGS. 1 and 2. In particular, panel 20 is a portion of the embossable layer of material 10 comprising only the embossing (or pixels) reflecting incoming light 24 at angle  $\alpha_1$ . Panel 22 is a portion of the embossable layer of material 10 comprising only the embossing (or pixels) reflecting incoming light 24 at angle  $\alpha_2$ . Panel 26 is a portion of the embossable layer of material 10 comprising only the embossing (or pixels) reflecting incoming light 24 at angle  $\alpha_3$ . Panel 28 is a portion of the embossable layer of material 10 comprising only the embossing (or pixels) reflecting incoming light 24 at angle  $\alpha_4$ . Material 10 can have as many panels as may be desirable. Generally



speaking, an embossing (or all pixels in a digital case) disposed within a particular panel are configured to reflect incoming light at a predetermined angle of reflection  $\alpha_n$ . As a result, the embossable layer becomes a multi-panel arrangement wherein each panel comprises the embossing (or the pixels embossed) to reflect incoming light at a certain angle, which is different from the angles of reflection of the embossings (or pixels) in other panels. The ribbon shown in FIG. 3 can comprise as many panels recorded at different angles as may be called for by a particular holographic or optically variable image that is desired to be custom printed on a substrate.

The tinting colors used to tint the individual panels are the primary colors (yellow-magenta-cyan-black, or YMCK, as they are known in the printing industry). Each individual holographic panel is tinted with one of the YMCK colors, making it so that each holographic dot transferred from the printing material to a substrate diffracts light in the direction in which its respective holographic panel diffracts light. As shown in FIG. 3, for example, panel 20 of material 10 is tinted with yellow, panel 22 of material 10 is tinted with magenta, panel 26 of material 10 is tinted with cyan, panel 28 of material 10 is tinted with black. Depending on the desired resulting color of a particular dot comprising a final image, the Y-M-C-K dots from their respective panels can be blended to provide that desired color. It is also possible not to blend the Y-M-C-K dots, but to provide the final image dots as individual dots from panels 20, 22, 26, or 28 depicted in FIG. 3. The visual effect of a final image consisting of the overlapped or stand alone tinted holographic dots will be the holographic appearance of natural coloration of a photo or any other desired image. In essence, printing with the printing material of the present invention will mimic all the coloration of a printing process, but with a holographic printing tape and the holographic appearance of the final image.

It should be noted that the number of pixels contained in a panel, or transferred onto the substrate), as well as the spectrum of various reflective angles, is directly related to the resolution of the resulting holographic or optically variable image and, ultimately, will need to have a reading device to read the image in case the resolution is too high or the difference between the angles are too close for a human eye to detect.

It is provided by the present invention that since each panel is characterized by an individual diffraction angle, each such panel can be assigned a number. For example, four

panels 20, 22, 26 and 28 in FIG. 3, characterized by the respective angles of reflection  $\alpha_1$ ,  $\alpha_2$ ,  $\alpha_3$ ,  $\alpha_4$ , can be assigned (or coded as) four predetermined numbers. In essence, four panels correspond to four angles of diffraction and to four coded numbers. The number of panels “4” here is completely arbitrary, it can be any number of the diffraction angles to infinity but usually 256 to correspond to the “gray scale” system used by design software like Coral draw and Photoshop.

If a holographic or optically variable printing ribbon 10 in FIG. 4 is used to create a customized image on a substrate, then the image will comprise pixels diffracting at up to 4 different angles  $\alpha_1$ ,  $\alpha_2$ ,  $\alpha_3$ ,  $\alpha_4$ . If the values of  $\alpha_1$ ,  $\alpha_2$ ,  $\alpha_3$ ,  $\alpha_4$  are far enough apart (for example,  $40^\circ$ ,  $100^\circ$ ,  $180^\circ$  and  $320^\circ$ , a human eye will easily be able to detect and visually confirm the four different colors comprising the image). If the values of the diffraction angles are close to each other (which can happen if the difference between only several recorded angles is small or if the number of different diffraction angles is large, up to 256, which makes the angular difference between the angles very small), the human eye will not be able to detect different colors and a dedicated reader will be required to verify the angles. If a reading device is used, the reader can detect any number of diffraction angles corresponding to pixels comprising the image. If the numbers are assigned to each diffraction angle, the reader device scans the image, reads (detects) and identifies the diffraction angles corresponding to the pixels in the image and outputs the sequence of numbers corresponding to the scanned image. A particular sequence of numbers corresponding to the diffraction angles can be coded as the ribbon’s serial number corresponding to the holographic printing material which was used to print the holographic or optically variable image. A particular sequence of numbers corresponding to a block of pixels in an image can also be coded as a security measure to verify the authenticity of a document and significantly reduce the possibility of counterfeiting. An identification mechanism (corresponding to the reader) can be incorporated into the ID card or document issuance machine so that this printer will only accept the predetermined or “serialized” ribbon. Thus, having a particular serial number (coded based on the numbers assigned to holographic panels), will also allow an investigator to know which printer was used to print a particular image and thus verify a document’s authenticity using the external reader.

It is now possible to see how the holographic or optically variable printing material can be used to ascertain the authenticity of a document or an ID card. A holographic or optically variable printing material, such as a ribbon, with multiple tinted panels characterized by the known diffraction angles and their respective assigned numbers is used to print an image in a pixel-by-pixel fashion on a desired substrate. Each image created by the described technique can have a specific ID zone, which is a block of pixels diffracting at the known (or designated) angles. The numbers corresponding to the known angles in the ID card can be scanned by the reading device and if the numbers match the known numbers for that ID zone, the authenticity of a document can be verified. For example, as schematically shown in FIG. 4, a holographic image 40 has an ID zone 42, which is also shown as an exploded view 44. The three pixels shown in exploded view 44 have diffraction angles  $20^\circ$ ,  $40^\circ$ , and  $60^\circ$ , respectively. If those diffraction angles are assigned three numbers, the reader scanning the image at ID zone 42 will detect the angles and the corresponding numbers. If the sequence of numbers matches that of a genuine document or ID card, the authenticity can be verified.

Holographic or optically variable images can be printed on a substrate using the holographic or optically variable printing materials of the present invention and can be designed using any typical known design software. After an image is designed in a digital format using the software, the image can be sent to a printer. Any conventional dye diffusion card printer (for example, Datacard, Fargo, Eltron, Atlantek, Kanematsu etc) can be used with the holographic or optically variable ribbon to print the image on a substrate. It is also contemplated that the printer with the holographic or optically variable printing material does not have to be in the same facility where the holographic image is designed. The image can be printed at a remote location where it can be sent to over the Internet, on a disk or transmitted by any other means. For example, as illustrated in FIG. 5, holographic or optically variable image 40 can be digitally designed pixel-by-pixel on computer 50. In a digitized design, it is specified that each pixel of image 40 will diffract incoming light at a predetermined angle. Then image 40 can be printed on a local (or LAN) printer 56 using the holographic printing material of the present invention, or sent over a network 52, such as the Internet, or shipped by other means, such as on a hard disk, to a remote location for printing on printer 54. An example of such a remote

location printing of image 40 could be a Department of Motor Vehicles or any other issuing or integration entity.

A method of forming a holographic or optically variable image on a substrate comprises the following. A multilayer holographic or optically variable tinted transfer material, which can be a ribbon or can have any other suitable shape and size, is provided as described above with regard to FIGS. 1-3. The holographic or optically variable image desired to be formed, or printed, on the substrate can be described as a number of pixels which form that image. In other words, the holographic or optically variable image is comprised of the image forming pixels. When a certain holographic image is being formed, or printed, on the substrate, each image forming pixel is transferred in a selective pixel transferring manner from the panel with the appropriate embossing (or in which such a pixel is disposed) to the substrate. As an illustration of the above-described method, the desired holographic or optically variable image can be formed by a pixel-by-pixel transfer process. Preferably, all the image forming pixels reflecting at the angle of reflection  $\alpha_1$  are transferred from a corresponding panel with the  $\alpha_1$  embossment. All the image forming pixels reflecting at the angle  $\alpha_2$  are transferred from a corresponding panel with the  $\alpha_2$  embossment and so on. In other words, when the holographic or optically variable image is being formed on the substrate, all of the image forming pixels from one panel can be transferred onto the substrate as a first step, then all of the image forming pixels from another panel can be transferred to the substrate and so on, depending on how many pixels of different reflecting angles are necessary for form a particular holographic or optically variable image. The pixel transfer process can be activated by heat, such as the heat generated by a thermal printer head. To achieve a "photo quality" image, tinted pixels from different individual panels could be blended to provide a holographic dot of a particular specified color. A particular color combination achieved by overlaying the holographic dots would be normally chosen and controlled by a computer.

For example, to produce the holographic or optically variable printing material in accordance with the present invention, each individual panel is recorded pixel-by-pixel using the same diffraction angle for all pixels using high-resolution format, for example 1200 dpi. The resulting panel would be of a size of a typical dye diffusion ribbon panel and have about 8,000,000 to 9,000,000 pixels of the same diffraction angle in each panel.

It should be noted that the resolution and the number of pixels per panel listed above are only an example of a possible panel, the resolution and the total number of pixels can vary depending on a type of document or substrate material or a particular application. The recorded panel is then embossed or cast into a coating that later is transferred pixel-by-pixel onto a substrate, such as a surface of an ID document by printing (issuing). The transfer of the pixels occurs in a pixel-by-pixel fashion under the heat and pressure from the print head at a lower resolution of between 200 and 500 dpi (for example, from the thermal print head), similarly to the technology currently employed by the card industry printing with dye diffusion ribbons. At the end, each printer would print at least 3 to 6 of the 1200 dpi pixels for each of the 200 to 500 dpi pixels of the resulting thermally printed image.

As it has already been described above, a computer can be provided to control the process of forming a holographic or optically variable image on a desired substrate. For example, the issuer can review the holographic or optically variable security image template on the computer display, add specific individual personal information to the template and then send the highly customized image from the computer to a holographic or optically variable printer (locally or remotely) to print the newly customized image on the desired substrate in accordance with the method described above. A highly customized holographic or optically variable image can be printed onto a desirable substrate, such as a paper or plastic document.

Variations and modifications of the foregoing are within the scope of the present invention. It is understood that the invention disclosed and defined herein extends to all alternative combinations of two or more of the individual features mentioned or evident from the text and/or drawings. All of these different combinations constitute various alternative aspects of the present invention. The embodiments described herein explain the best modes known for practicing the invention and will enable others skilled in the art to utilize the invention. The claims are to be construed to include alternative embodiments to the extent permitted by the prior art.

Various features of the invention are set forth in the following claims.